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Indian Standard

SPECIFICATION FOR WOVEN ROVING GLASS FABRIC FOR POLYESTER-GLASS LAMINATES FOR AEROSPACE PURPOSES

UDC 677·521·064 : 678·674-419 : 629·13

INDIAN STANDARDS INSTITUTION
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Indian Standard

SPECIFICATION FOR WOVEN ROVING GLASS FABRIC FOR POLYESTER-GLASS LAMINATES FOR AEROSPACE PURPOSES

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SPECIFICATION FOR
WOVEN ROVING GLASS FABRIC FOR
POLYESTER-GLASS LAMINATES FOR
AEROSPACE PURPOSES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 5 February 1983, after the draft finalized by the Textile Materials for Aerospace Purposes Sectional Committee had been approved by the Textile Division Council.

0.2 In the preparation of this standard, considerable assistance has been derived from the following publications:

> BS 3396 : Part 3 : 1970 Specification for woven glass fibre fabrics for plastics reinforcement : Part 3 Finished fabrics for use with polyester resin systems. British Standards Institution.

> BS 3691 : 1969 Specification for glass fibre rovings for the reinforcement of polyester and of epoxide resin systems. British Standards Institution.

> ASTM D2150-81 Specification for woven roving glass fabric for polyester — glass laminates. American Society for Testing and Materials.

0.3 The Standards of Weights and Measures Act, 1976 stipulates the use of International System of Units in the country. In order to familiarize the industry with this system, the recommended SI units for use in the textile industry are given in Appendix E.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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*Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard covers requirements for woven fabrics made from glass rovings that are intended for use in laminated plastics for aerospace purposes.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Roving — A plurality of parallel strands*.

2.2 Strand — A plurality of filaments bonded with a size.

2.3 Filament — A single glass fibre as drawn.

2.4 Size — Materials applied to the strand during manufacture to facilitate processing and use.

2.5 Coupling Agent — Additive to improve performance of the roving in use.

2.6 Roving Count (Tex) — The mass in grams per kilometre of roving.

3. TYPES

3.1 This standard covers 8 types of fabrics.

4. MANUFACTURE

4.1 Filament Diameter — The diameter of the filaments used in the roving should be between 8·75 and 15·0 μm. The usual diameter range are as follows:

8·75 μm up to but not including	10·0
10·0 μm up to but not including	11·25
11·25 μm up to but not including	12·5
12·5 μm up to but not including	13·75
13·75 μm up to but not including	15·0

4.2 Roving Construction — The roving construction shall be as agreed to between the purchaser and the supplier. The filament diameter should

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*By reason of the method of manufacture, the strands generally contain a small amount of twist not exceeding 4 turns/m (1/10 of a turn per inch).

be within the range specified in **4.1,** but other diameters may be supplied by agreement between the buyer and the seller.

4.3 Binder — The glass rovings used to make the fabrics shall contain a sizing to facilitate weaving and to impart high wet strength to laminates. Unless otherwise specified, the sizing shall be compatible with a polyester laminating resin selected by the supplier of the woven roving. When specified, the sizing shall be compatible with particular polyester (or other type) resin specified in the purchase order. When so specified, the test laminate shall be made with that resin and the purchase order shall specify its dry and wet flexural strengths.

4.4 Coupling Agent — A coupling agent, such as methacrylatochromic chloride (chrome) or a silane or both, shall be incorporated in the size applied to the strand during manufacture.

5. REQUIREMENTS

5.1 Workmanship and Finish — The fabric should be uniformly woven. The selvedges should be well-made, substantially straight and even, and should have approximately the same tension as the remainder of the fabric. The fabric should be substantially free from thick and thin places, holes, smashes, grease and oil spots and other contamination, torn selvedges; and any other such defects as are detrimental to its end use.

5.2 Width — The width and the fabric shall be as agreed to between the purchaser and the supplier, with a tolerance of ± 13 mm.

5.3 Mass and Roll Length — The fabric shall conform to the requirements for mass and roll length prescribed in Table 1.

5.4 Roving Count — The roving count shall be as given in Table 2, when determined by the method prescribed in Appendix A.

5.5 Flexural Strengths of Laminates — The properties of the fabric shall be such that when resin laminates are fabricated and tested as specified in Appendix B, the test results shall meet the requirements prescribed in Table 3.

5.6 Moisture Content — The moisture content of the woven roving glass fabric when tested by the following method as prescribed in Appendix C shall meet the requirement given in Table 4.

5.7 Loss on Ignition — The loss on ignition of the woven roving glass fabric when tested by following the method as prescribed in Appendix D shall meet the requirement given in Table 4.

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TABLE 1   MASS AND DIMENSIONAL REQUIREMENTS OF WOVEN ROVING GLASS FABRICS

(*Clause* 5.3)

TYPE	MASS	LENGTH OF THE ROLL, *Min*
(1)	(2)	(3)
	(g/m²)	m
1	441	91·5
2	542	91·5
3	831 ·	68·5
4	831	68·5
5	915	59·5
6	610	68·5
7	745	68·5
8	610	68·5
Tolerance	± 10 percent	—
Methods of Test	IS : 1964-1970*	IS : 1954-1969†

*Methods for determination of weight per square metre and weight per linear metre of fabrics (*first revision*).

†Methods for determination of length and width of fabrics (*first revision*).

TABLE 2   TYPES AND CONSTRUTIONS OF WOVEN ROVING GLASS FABRICS

(*Clause* 5.4)

TYPE	WEAVE	ROVING COUNT	
		Warp	Weft
(1)	(3)	(3)	(4)
		tex	tex
1	Plain	759 to 842	929 to 1069
2	Plain	759 to 842	1 506 to 1 685
3	Plain	2 071 to 2 367	2 312 to 2 687
4	Plain	2 071 to 2 367	3 107 to 3 551
5	Plain	2 071 to 2 367	4 734 to 4 971
6	Plain	1 841 to 1 212	1 156 to 1 344
7	Plain	2 071 to 2 367	1 912 to 2 167
8	Plain	2 071 to 2 367	1 560 to 1 657
Method of Test		Appendix A	

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TABLE 3 MINIMUM FLEXURAL STRENGTH FOR 3.17 mm THICK POLYESTER LAMINATES MADE WITH WOVEN ROVING GLASS FABRICS

(*Clause 5.5*)

TYPE	FLEXURAL STRENGTH, *Min*			
	Length wise		Cross wise	
	Dry	Wet	Dry	Wet
(1)	(2)	(3)	(4)	(5)
	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²
1	4 220	2 820	1 760	1 050
2	3 900	2 110	3 160	1 410
3	3 520	2 110	2 820	2 110
4	3 520	2 110	3 160	1 410
5	3 520	2 110	2 840	2 110
6	2 820	2 110	2 110	1 410
7	3 520	2 110	3 160	2 110
8	3 520	2 110	2 110	1 410
Method of Test	Appendix B			

The thickness of polyester laminate for type-5 shall be 2·79 mm instead of 3·17 mm. A tolerance of ± 0·25 mm shall be allowed on the laminate thickness.

TABLE 4 OTHER REQUIREMENTS OF WOVEN ROVING GLASS FABRIC

(*Clauses* 5.6, 5.7 *and* 5.8)

SL No.	CHARACTERISTIC	REQUIREMENT	METHOD OF TEST
(1)	(2)	(3)	(4)
i)	Moisture content, percent, *Max*	±0·3	Appendix C
ii)	Loss on ignition	As declared, with a tolerance of ± 20 percent or ± 0·2 whichever is greater	Appendix D
iii)	Conductivity of water extract, mS/m* *Max*	12·5 mS/m*	IS : 4420-1967†

* 1mS/m == 10 micromhos/cm.

†Methods for determination of conductivity of aqueous and organic extracts of textile materials.

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5.8 Conductivity of Water Extract — The conductivity of water extract of the woven roving glass fabric when tested by following the method as prescribed in IS : 4420-1967* shall meet the requirement given in Table 4.

6. PACKING

6.1 The fabric shall be packed in the form of rolls weighing not more than 500 kg each. No roll shall contain more than 3 pieces of the finished fabric and no piece shall be less than 20 m in length. The fabric shall be rolled evenly on tubes of sufficient length and strength to produce firm packages so as to prevent collapsing or telescoping during transit, storage and handling. Both ends of the rolls shall be suitably protected to prevent damage to the edges of the cloth. The rolls shall be packed in moisture-proof containers.

7. MARKING

7.1 Each roll of the fabric shall be marked with the following:

a) Type;

b) Date of manufacture;

c) Nominal (declared) width;

d) Length;

e) Loss on ignition;

f) Flexural strength, if declared;

g) Manufacturer's identification code.

7.1.1 The rolls may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

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*Methods for determination of conductivity of aqueous and organic extract of textile materials.

APPENDIX A

(*Clause* 5.4)

DETERMINATION OF ROVING COUNT

A-1. Maintaining a length of roving under sufficient tension to ensure that it is straight, cut off a 1-m length, measured with an accuracy of $\pm$ 1 percent.

A-2. Weigh the cut length to the nearest 5 mg and report this mass in milligrams as the roving (Tex).

APPENDIX B

(*Clause* 5·5)

PREPARATION AND TESTING OF RESIN-GLASS FABRIC LAMINATE FOR FLEXURAL STRENGTH

B-1. GENERAL

B-1.1 A test laminate of $3\cdot17 \pm 0\cdot25$ mm thickness and 30×30 cm shall be prepared using sufficient number of glass cloth and polyester resin with a suitable catalyst and accelerator. The proportion of resin hardener and accelerator and subsequent curing of the laminate shall be in accordance with the instructions of the resin manufacturer. The glass fabric cut to size shall be dried in a ventilated oven for 1 hour at $100 \pm 5°C$, cooled in a desiccator and used immediately on removal. The fabric shall be impregnated with the resin to give a final resin content of 35 to 42 percent of the total weight when determined by ignition at $575 \pm 25°C$. The laminating shall be done at an ambient temperature of 17 to 25°C.

B-2. PREPARATION OF LAMINATE

B-2.1 A suitable method for preparation of laminate is given in **B-2.1.1** and **B-2.1.2**.

B-2.1.1 Calculate the mass of resin necessary to give the required resin content from the mass of glass cloth to be used. Cover a polished metal plate of size 40×40 cm with a layer of regenerated cellulose film of $0\cdot05$ mm thicken. Lay on it a layer of dried glass cloth of suitable size. Poured sufficient amount of catalyzed resin on to the centre of the cloth and spread out uniformly with a roller or thin metal strip

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until the cloth is evenly coated. Repeat the procedure with alternate layers of resin and glass cloth and with successive layers of cloth superimposed on the previous one with the warp threads parallel to those in the preceding ply. The whole process should not take more than 20 minutes.

B-2.1.2 Cover the top layer with a layer of regenerated cellulose fibre followed by a second polished metal plate. Place metal stops 3 mm thick between the lower and upper metal plates. Place the whole build-up between the platens of a press and hold under a pressure of approximately 0·5 kg cm² during the curing schedule. After curing the laminate in accordance with the resin manufacturer's instructions, give a post-cure at 100°C for 2 hours.

B-3. DETERMINATION OF FLEXURAL STRENGTH OF LAMINATE

B-3.1 Test Specimens — Cut ten rectangular strips, measuring 100×15 mm, from the laminate with the longer direction parallel to the warp or weft for determining the flexural strength of the strips.

B-3.2 Conditioning of Test Specimens — Condition the specimens to be tested in the 'dry condition' for not less than 24 hours in an atmosphere of 65 ± 2 percent relative humidity and $27 \pm 2°C$ temperature prior to testing, and test in the same conditions.

B-3.2.1 Immerse the specimens to be tested in the 'wet condition' in boiling distilled water for 2 hours and allow to cool to room temperature in the same water. Conduct the test on the wet specimens immediately after removal from water.

B-3.3 Apparatus — A suitable flexural strength testing machine with a bend jig, which will permit the span being varied to suit the thickness of the specimens, is used. The machine shall be properly calibrated and the error, if any, in the load measuring system shall not exceed ± 1 percent of the applied load. The contact surfaces of the supports and loading blocks shall be of a radius of $3·2 \pm 0·2$ mm and shall not be less than 25 mm in length from each end.

B-3.4 Measurement of Dimensions — The breadth and thickness at the centre of the span shall be measured to the nearest 0·01 mm. The span shall be measured to the nearest 0·2 mm.

B-3.5 Procedure — Place the specimen symmetrically over the supports in the bend jig (*see* Fig. 1) which are 50 mm apart (between 16 to 18 times the thickness of the specimen). Align the loading block and the supports so that the axes of the cylindrical surfaces are parallel and the

loading block is midway between the supports. Apply the load to the specimen at a cross-head rate of 5 to 6·5 mm/min till it fractures. The load at fracture shall be noted.
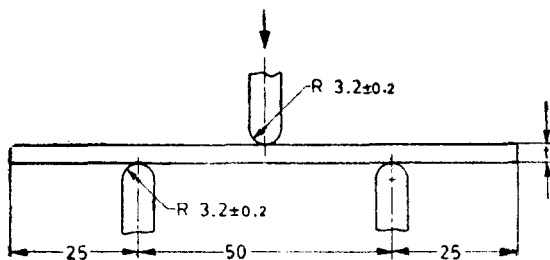
$t =$ Thickness of specimen

All dimensions in millimetres.

FIG. 1   FLEXURAL TEST FOR RESIN-GLASS FIBRE LAMINATE

B-3.6 Calculation and Reporting — The flexural atrength or the modulus of rupture in bending is the maximum load sustained by the specimen converted to the maximum fibre stress. It is calculated using the following formula:

$$S = 15 \times \frac{wl}{bt^2}$$

where

$S =$ flexural strength in Mn/m^2,

$w =$ load at fracture in N,

$l =$ span in mm,

$b =$ breadth of the specimen in mm, and

$t =$ thickness of specimen in mm.

B-3.6.1 The average of five determinations in each direction and tested in each state, that is, dry and wet, shall be reported as the flexural strength.

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APPENDIX C

(*Clause* 5.6)

DETERMINATION OF MOISTURE CONTENT

C-1. Weigh to the nearest 5 mg, about 10 g of the sample. Place the sample in a forced draught oven at 105 ± 2°C for 30 minutes. Reweigh the sample either without removing from the oven but with the air flow stopped, or in a stoppered container after cooling. Calculate the moisture content as follows:

$$\text{Moisture content, percent by mass} = \frac{A - B}{A} \times 100$$

where

A = original mass in g of the sample, and

B = mass in g of the oven-dried sample.

C-1.1 The dried roving shall be used for determination of loss on ignition.

APPENDIX D

(*Clause* 5.7)

DETERMINATION OF LOSS ON IGNITION

D-1. Heat the oven dried sample of the fabric obtained from the determination of moisture content (*see* **C-1.1**), at 575 ± 25°C to ignite the size. Cool in a desiccator and reweigh to the nearest 5 mg. Calculate the loss on ignition as follows:

$$\text{Loss on ignition, percent by mass} = \frac{B - C}{B} \times 100$$

where

B = mass in g of the oven-dried sample, and

C = mass in g of the sample after ignition.

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APPENDIX E

(*Clause* 0.3)

RECOMMENDED SI UNITS FOR TEXTILES

Sl No.	Characteristic	SI Unit		Application
		Unit(s)	Abbreviation(s)	
(1)	(2)	(3)	(4)	(5)
1.	Length	Millimetre	mm	Fibres
		Millimetre, centimetre	mm, cm	Samples, test specimens (as appropriate)
		Metre	m	Yarns, ropes, cordage, fabrics
2.	Width	Millimetre	mm	Narrow fabrics
		Centimetre	cm	Other fabrics
		Millimetre, centimetre	mm, cm	Samples, test specimens (as appropriate) Carpets, druggets, *DURRIES* (as appropriate)
3.	Thickness	Micrometre (micron)	μm	Delicate fabrics
		Millimetre	mm	Other fabrics, carpets, felts
4.	Linear density	Tex	tex	Yarns
		Millitex	mtex	Fibres
		Decitex	dtex	Filaments, filament yarns
		Kilotex	ktex	Slivers, ropes, cordage
5.	Diameter	Micrometre (micron)	μm	Fibres
		Millimetre	mm	Yarns, ropes, cordage

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Sl No.	Characteristic	SI Unit		Application
		Unit(s)	Abbreviation(s)	
(1)	(2)	(3)	(4)	(5)
6.	Circumference	Millimetre	mm	Ropes, cordage
7.	Threads in fabric:			Woven fabrics (as appropriate)
	a) Lengthwise	Number per centimetre	ends/cm	
		Number per decimetre	ends/dm	
	b) Widthwise	Number per centimetre	picks/cm	
		Number per decimetre	picks/dm	
8.	Warp threads in loom	Number per centimetre	ends/cm	Reeds
9.	Stitches in knitted fabric:			Knitted fabrics (as appropriate)
	a) Lengthwise	Courses per centimetre	courses/cm	
		Courses per decimetre	courses/dm	
	b) Widthwise	Wales per centimetre	wales/cm	
		Wales per decimetre	wales/dm	
10.	Stitch length	Millimetre	mm	Knitted fabrics, made-up items
11.	Mass per unit area	Grams per square metre	g/m²	Fabrics
12.	Mass per unit length	Grams per metre	g/m	Fabrics

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Sl No.	Characteristic	SI Unit		Application
		Unit(s)	Abbreviation(s)	
(1)	(2)	(3)	(4)	(5)
13.	Twist	Turns per centimetre	turns/cm	Yarns, ropes, cordage (as appropriate)
		Turns per metre	turns/m	
14.	Test or gauge length	Millimetre, centimetre	mm, cm	Fibre, yarn and fabric specimens (as appropriate)
15.	Breaking load	Millinewton	mN	Fibres, delicate yarns (individual or skeins)
		Newton	N	Strong yarns (individual or skeins), ropes, cordage, fabrics
16.	Breaking length	Kilometre	km	Yarns
17.	Tenacity	Millinewton per tex	mN/tex	Fibres, yarns (individual or skeins)
18.	Twist factor or twist multiplier	Turns per centimetre × square root of tex	turns/cm × $\sqrt{\text{tex}}$	Yarns (as appropriate)
		Turns per metre × square root of tex	turns/m × $\sqrt{\text{tex}}$	
19.	Bursting strength	Newton per square centimetre	N/cm²	Fabrics

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Sl No.	Characteristic	SI Unit		Application
		Unit(s)	Abbreviation(s)	
(1)	(2)	(3)	(4)	(5)
20.	Tear strength	Millinewton, newton	mN, N	Fabrics (as appropriate)
21.	Pile height	Millimetre	mm	Carpets
22.	Pile density	Mass of pile yarn in grams per square metre per millimetre pile height	$g/m^2/mm$ pile height	Pile carpets
23.	Elastic modulus	Millinewton per tex per unit deformation	mN/tex/unit deforma- tion	Fibres, y a r n s, strands